TITLE OF THE INVENTION

POSITION DETECTION APPARATUS AND

EXPOSURE APPARATUS

5   FIELD OF THE INVENTION

The present invention relates to a position detection apparatus for detecting the position of a mark on an object and an exposure apparatus using the position detection apparatus.

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BACKGROUND OF THE INVENTION

In an exposure apparatus for manufacturing, e.g., semiconductor devices that are increasingly shrinking in their feature sizes, before a reticle pattern is projected

15   on a wafer by exposure, the wafer and reticle are aligned.

Alignment includes two techniques: pre-alignment and fine alignment. In pre-alignment, a feed shift amount generated when a wafer is loaded from a wafer conveyor apparatus onto a wafer chuck on a stage in a semiconductor

20   exposure apparatus is detected, and the wafer is coarsely aligned within an accuracy with which subsequent fine alignment can be normally processed. In fine alignment, the position of the wafer placed on the wafer chuck on the stage is accurately measured, and the wafer and reticle are

25   precisely aligned such that the alignment error between the wafer and reticle fall within the allowable range. The

pre-alignment accuracy is, e.g., about 3 μm. The fine
alignment accuracy is, e.g., 80 nm or less for a 64 MDRAM
although it changes depending on the requirement for wafer
work accuracy.

5   Pre-alignment requires detection in a very wide range
because the wafer feed shift generated when the conveyor
apparatus feeds a wafer onto the chuck is detected, as
described above. The detection range is generally about
500 μm squared. As a method of detecting the X- and
10   Y-coordinates of one mark and performing pre-alignment,
pattern matching is often used.

       Pattern matching is roughly classified into two
techniques. In one technique, a mark image is binarized,
the binary image is matched with a predetermined template,
15   and a position at which the binary image and template have
the highest correlation is determined as a mark position.
In the other technique, the correlation between a mark image
that remains a grayscale image and a template having
grayscale information is calculated. As the latter method,
20   normalization correlation is often used.

       In pre-alignment, the mark to be used must be small
although the detection range is very wide. This is because
as a pattern other than a semiconductor element is used as
a mark, the mark is preferably as small as possible to make
25   the semiconductor element area as large as possible. Hence,
the mark is often laid out in a region that is not used as

an element, e.g., on a scribing line. The mark size is therefore limited by the scribing line width.

The scribing line width is becoming narrower year by year because of the high efficiency of semiconductor manufacturing and improved work accuracy in recent years. Currently, the scribing line width is as small as 100 μm or less, and accordingly, the mark size is also 60 μm or less.

On the other hand, to manufacture a semiconductor device with high density, a wafer is processed through new processes.

A problem associated with pre-alignment mark detection will be described with reference to Figs. 6A to 6H. Fig. 6A shows a layout in which a semiconductor element pattern is adjacent outside a cross-shaped mark 100, in which a portion win long in the horizontal direction is a signal detection region. Figs. 6B and 6D show detection signal waveforms, and Figs. 6C and 6E show the wafer sectional structures corresponding to the signals shown in Figs. 6B and 6D. Fig. 6F also shows the cross-shaped detection mark 100. Fig. 6G shows the detection signal waveform. Fig. 6H shows the wafer sectional structure corresponding to Fig. 6G.

Fig. 6E shows the sectional structure of the mark after an ultra low step process. Fig. 6H shows the sectional structure of the mark after a CMP process. In

these examples, it is difficult to detect the pre-alignment mark.

In pre-alignment, generally, a mark once formed is continuously used for position detection even in the subsequent processes. However, as layers are deposited on the mark, it gradually becomes hard to observe the mark. In the sectional structure shown in Fig. 6E, since a mark having low reflectivity and small step difference is present in a material having high reflectivity and large step difference, the mark can hardly be detected. In addition, since various layers are deposited on the mark, the image obtained by reading the mark may have low contrast and much noise.

The examples shown in Figs. 6A to 6H suggest that along with the progress in the technique of manufacturing a semiconductor device with high density, processes that make detection of a pre-alignment mark present in a wide detection range by the conventional pattern matching hard have emerged and they present problem.

For example, as shown in Fig. 6E, when the mark has a small step difference although the peripheral pattern has a large step difference and high reflectivity, an image signal shown in Fig. 6D is obtained. The image signal shown in Fig. 6D is a signal in the region win shown in Fig. 6A, which is obtained by sensing the pre-alignment mark 100 irradiated by dark field illumination. The ordinate

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represents a video signal voltage, and the abscissa represents a coordinate. When the signal is binarized using a predetermined threshold value, the mark disappears because the signal level of the mark portion is low. For

5   this reason, the mark cannot be recognized by template matching.

Even with normalization correlation which is known as a detection method for a grayscale image, it is also difficult to detect a mark in an image with small step

10   difference and low contrast or a noisy image. Especially, the detection rate of normalization correlation tends to be low when the influence of noise is large, or mark defects occur in the wafer process. Additionally, the process time is long because of the complex calculation method.

Various approximation calculations have also been

15   examined to solve the above problem. However, the problem of low detection rate for a low-contrast image remains unsolved.

Another well-known mark detection method is the

20   vector correlation method (Video Information 1992/2). The vector correlation method can obtain a high detection rate even when the mark image has noise or the mark has a defect. In the vector correlation method, attribute information representing the feature of edge information is extracted

25   together with the edge of the mark. With this correlation calculation method, the extracted feature is compared with

a template to detect the mark position.

In the vector correlation method, a high-contrast mark and low-contrast mark cannot be detected using the same parameter in extracting the edge information of the marks.

5   Hence, the edge extraction parameter need be tuned.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the above situation, and has as its object to stably

10   detect the position of a mark even in a mark image that is difficult to detect, e.g., a low-contrast mark image, a noisy mark image, or a mark image whose mark has a defect generated in the wafer process. Especially in association with the vector correlation method, it is another object

15   of the present invention to optimize a mark detection method in accordance with a mark image in extracting information related to an edge and stably detect the mark position and, more specifically, to cope with any mark image by self learning and stably detect the mark position.

20   According to the first aspect of the present invention, there is provided a position detection apparatus for detecting a position of a mark on an object, comprising an extraction section for observing the mark and extracting a plurality of edge information of the mark in

25   correspondence with attribute information representing features of the edge information, respectively, a position

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determination section for comparing each edge information with one of a plurality of templates, which is specified by attribute information corresponding to the edge information and evaluating a plurality of comparison

5   results obtained by comparison to determine the position of the mark, and a control section for changing at least one of an extraction rule in the extraction section and an evaluation rule in the position determination section on the basis of the plurality of comparison results by the

10 position determination section and causing the extraction section and the position determination section to execute processing again.

In the position detection apparatus according to the first aspect of the present invention, each attribute

15 information preferably represents an edge portion of the mark, which is associated with the corresponding edge information. In addition, each attribute information preferably represents one of a plurality of extraction conditions under which the corresponding edge information

20 is extracted.

In the position detection apparatus according to the first aspect of the present invention, preferably the extraction section extracts, as each edge information, information representing an edge position shifted from an

25 actual edge position of the mark by a predetermined distance in one of a plurality of predetermined directions, and each

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attribute information represents a direction in which an edge position associated with the corresponding edge information shifted from the actual edge position of the mark by the predetermined distance.

5   In the position detection apparatus according to the first aspect of the present invention, the extraction section preferably comprises an image sensing section for sensing an image of the mark, a differential processing section for differentiating the mark image as an image

10   sensing result, and an edge information generation section for processing the differential result to generate the edge information corresponding to the attribute information.

Preferably, the differential processing section calculates a change rate of an image signal of the mark image

15   along at least two directions of the mark image, and each attribute information is associated with one of the at least two directions.

Alternatively, each attribute information is preferably associated with a sign of the differential

20   result by the differential processing section.

Alternatively, preferably the differential processing section calculates a change rate of an image signal of the mark image across the mark image along row and column directions of the mark image, and each attribute

25   information is associated with one of the row and column directions and the differential result by the differential

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processing section.

In the position detection apparatus according to the first aspect of the present invention, each template preferably includes, as information to be compared with the edge information, position information of a plurality of points defining a corresponding edge.

In the position detection apparatus according to the first aspect of the present invention, the extraction section preferably performs noise removal processing for an observation result of the mark and then executes edge information extraction.

In the position detection apparatus according to the first aspect of the present invention, the extraction section preferably increases a line width associated with the extracted edge information.

In the position detection apparatus according to the first aspect of the present invention, the extraction rule and/or the evaluation rule determined by the control section is preferably stored in a memory and used as a base for processing to be executed later.

In the position detection apparatus according to the first aspect of the present invention, the extraction section preferably observes the mark under dark field illumination.

According to the second aspect of the present invention, there is provided a position detection apparatus

for detecting a position of a mark on an object, comprising an extraction section for observing the mark and extracting edge information of the mark, a position determination section for comparing the edge information with a template and evaluating a comparison result to determine the position of the mark, and a control section for changing at least one of an extraction rule in the extraction section and an evaluation rule in the position determination section on the basis of the evaluation result by the position determination section and causing the extraction section and the position determination section to execute processing again.

According to the third aspect of the present invention, there is provided an exposure apparatus comprising a projection optical system for projecting a pattern onto a substrate, a chuck on which the substrate is placed, and a position detection section for detecting a position of a mark on the substrate placed on the chuck, wherein the substrate is aligned on the basis of a detection result by the position detection section, and then, the substrate is exposed using the pattern, the position detection section comprising an extraction section for observing the mark and extracting a plurality of edge information of the mark in correspondence with attribute information representing features of the edge information, respectively, a position determination section for

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comparing each edge information with one of a plurality of templates, which is specified by attribute information corresponding to the edge information and evaluating a plurality of comparison results obtained by comparison to

5   determine the position of the mark, and a control section for changing at least one of an extraction rule in the extraction section and an evaluation rule in the position determination section on the basis of the plurality of comparison results by the position determination section

10   and causing the extraction section and the position determination section to execute processing again.

In the exposure apparatus according to the third aspect of the present invention, the extraction section of the position detection section preferably observes the mark

15   with an off-axis scope or TTR (Through The Reticle) or TTL (Through The Lens).

According to the fourth aspect of the present invention, there is provided an exposure apparatus comprising a projection optical system for projecting a

20   pattern onto a substrate, a chuck on which the substrate is placed, and a position detection section for detecting a position of a mark on the substrate placed on the chuck, wherein the substrate is aligned on the basis of a detection result by the position detection section, and then, the

25   substrate is exposed using the pattern, the position detection section comprising an extraction section for

observing the mark and extracting edge information of the mark, a position determination section for comparing the edge information with a template and evaluating a comparison result to determine the position of the mark,

5   and a control section for changing at least one of an extraction rule in the extraction section and an evaluation rule in the position determination section on the basis of the evaluation result by the position determination section and causing the extraction section and the position

10 determination section to execute processing again.

According to the fifth aspect of the present invention, there is provided a position detection method of detecting a position of a mark on an object, comprising the extraction step of observing the mark and extracting

15 a plurality of edge information of the mark in correspondence with attribute information representing features of the edge information, respectively, the position determination step of comparing each edge information with one of a plurality of templates, which is

20 specified by attribute information corresponding to the edge information and evaluating a plurality of comparison results obtained by comparison to determine the position of the mark, and the control step of changing at least one of an extraction rule in the extraction step and an

25 evaluation rule in the position determination step on the basis of the plurality of comparison results in the position

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determination step and causing the extraction step and the position determination step to execute processing again.

According to the sixth aspect of the present invention, there is provided a position detection method

5   of detecting a position of a mark on an object, comprising the extraction step of observing the mark and extracting edge information of the mark, the position determination step of comparing the edge information with a template and evaluating a comparison result to determine the position

10   of the mark, and the control step of changing at least one of an extraction rule in the extraction step and an evaluation rule in the position determination step on the basis of the evaluation result in the position determination step and causing the extraction step and the

15   position determination step to execute processing again.

Further objects, features and advantages of the present invention will become apparent from the following detailed description of the embodiments of the present invention with reference to the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow chart of image processing in an exposure apparatus according to a preferred embodiment of the present invention;

25   Figs. 2A to 2C are schematic views of exposure apparatuses according to preferred embodiments;

Fig. 3 is a view for explaining mark edge extraction processing in the preferred embodiment of the present invention;

Fig. 4A is a view showing synthesized edge portions extracted from a pre-alignment mark image;

Figs. 4B to 4E are views showing edge components (edge information) extracted from the pre-alignment mark image;

Fig. 5A is a view showing synthesized templates according to the preferred embodiment of the present invention;

Figs. 5B to 5E are views showing templates according to the preferred embodiment of the present invention; and

Figs. 6A to 6H are views showing pre-alignment marks and their step differences and video signals.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 2A is a view showing the schematic arrangement of a semiconductor exposure apparatus according to a preferred embodiment of the present invention. In this exposure apparatus, a mark for pre-alignment is detected using an off-axis scope 6.

A pattern for exposure is formed on a reticle 1. The pattern is illuminated with, e.g., an i-line or excimer laser light source of an illumination system (not shown) and projected onto a wafer 5 through a projecting lens 2.

Pre-alignment is performed after the wafer 5 is

placed on a wafer chuck 4 on an X-Y stage 3 by a wafer conveyor

apparatus (not shown). Since the wafer 5 is placed on the

wafer chuck 4 at the accuracy depending on the conveyor

5   apparatus, the alignment accuracy is low. Hence, accurate

wafer position measurement cannot be directly started. To

do this, a pre-alignment (coarse alignment) mark on the

wafer is observed with the off-axis scope 6 arranged outside

the projecting lens 2, the optical image of the mark is

10   photoelectrically converted by a CCD camera 7, and then the

position information of the mark is detected by a

pre-alignment image processing unit 8. In the

pre-alignment image processing unit 8, the

photoelectrically converted video signal is converted into

15   digital information by an A/D conversion unit 71, and the

pre-alignment mark position is detected by an image

processor 72 having an image memory.

It is advantageous when both the X- and Y-coordinates

can be detected by one mark. For this reason, the

20   pre-alignment mark has the same shape as that of the mark

100 shown in Fig. 6A. The position of the X-Y stage 3 when

the pre-alignment mark image is caputured is accurately

measured by a laser interferometer 12. On the basis of the

mark position shift and the position of the X-Y stage 3,

25   a controller 9 accurately measures the shift amount of the

wafer 5 placed on the chuck 4. The X-Y stage 3 is driven

by a stage driving unit 13.

In this embodiment, a case wherein dark field illumination is employed as illumination for the off-axis scope 6 will be described. In dark field illumination,
5   scattered light from an edge position of the mark step difference is received by the CCD camera 7. The present invention can also be applied to bright field illumination.

Fig. 1 shows the flow of image processing (position detection processing) for executing pre-alignment in a
10 position detection apparatus according to the preferred embodiment of the present invention and a semiconductor exposure apparatus using the position detection apparatus.

First, the vector correlation method (S100, S101, S102) will be described.
15 In step S100, the image processor 72 executes edge extraction processing for an image captured by the CCD camera 7. In edge extraction processing, both the edge information of the mark image and attribute information representing that the edge information is associated with
20 the upper, lower, right, or left side of the mark image are simultaneously acquired.

In this embodiment, edge information (solid lines in Figs. 4B to 4E) are made to correspond to attribute information ("over", "under", "left", and "right" in
25 Figs. 4B to 4E) and extracted for four directions of the upper, lower, left, and right sides of an actual edge of

the mark image.   Edge information may be made to correspond
to attribute information and acquired not only for the four
directions of the upper, lower, left, and right sides of
an actual edge but also for, e.g., four directions that
5   respectively make an angle of 45° with the above four
directions, i.e., a total of eight directions.
Alternatively, edge information may be made to correspond
to attribute information and acquired according to another
rule.

10   In step S101, the mark image is searched on the basis
of edge information and attribute information
corresponding to the edge information. Searching means
detection of an approximate position of the mark image.   In
searching the mark image, the degree of matching between
15   the edge information extracted in step S100 and a template
specified by the attribute information corresponding to the
edge information is occasionally calculated while moving
the template within a predetermined region, and the center
coordinates of the mark (center coordinates of the
20   template) at which the maximum degree of matching is
obtained are determined. Each template is formed from
feature points of interest corresponding to attribute
information, to which attention must be paid in comparison
with the edge information extracted from the mark image.
25   To calculate the degree of matching, the edge
information (e.g., Fig. 4B) extracted in step S100 is

compared to corresponding feature points of interest (e.g.,

Fig. 5B) in the template to determine whether the two pieces

of information match, and the comparison results are

evaluated. More specifically, the degree of matching is

5   calculated by comparing the edge information shown in

Fig. 4B with the feature points of interest of the template

shown in Fig. 5B, the edge information shown in Fig. 4C with

the feature points of interest of the template shown in

Fig. 5C, the edge information shown in Fig. 4D with the

10   feature points of interest of the template shown in Fig. 5D,

and the edge information shown in Fig. 4E with the feature

points of interest of the template shown in Fig. 5E while

changing the center coordinates (position of +) and

evaluating the number of matches obtained. The center

15   coordinates of a template, at which the maximum degree of

matching is obtained, is detected as the position of the

mark image.

It is determined in step S102 whether mark position

search is successful. More specifically, when the

20   matching result (maximum degree of matching) has a value

equal to or larger than a threshold value for detection

determination, it is determined that mark position

detection is successful, and the position of the mark is

precisely measured in step S103.

25   Mark position search fails in step S102 when 1) the

matching result (maximum degree of matching) has a value

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smaller than the threshold value for detection
determination or 2) a degree of matching equal to or higher
than the level of threshold value for detection
determination is obtained at a plurality of mark positions,

5   and one of them cannot be selected.

Processing of a characteristic feature of the present
invention starts from step S104.

If mark position search fails, the flow advances to
the loop including step S104 to change parameters for

10   detection, i.e., adjust one or both of the edge extraction
processing parameter and the threshold value for detection
determination, and edge extraction (S100), mark position
search (S101), and detection determination (S102) are
performed again. The repetitive loop of parameter change

15   and search is controlled on the basis of the number of times
or conditions set in advance. If it is determined that the
mark position cannot be accurately detected any more even
by repeating the repetitive loop, a detection error occurs.

Actual processing according to the flow will be

20   described next with reference to Figs. 3 and 4A to 4E.
First, vector correlation will be described. In edge
extraction in step S100, scattered light from the mark 100
is received and photoelectrically converted by the CCD
camera 7, then A/D-converted by the A/D conversion unit 71,

25   and stored in the image memory of the processor 72.

An image signal along a given scanning line (row) of

the stored image is represented by Xi. Since this
embodiment employs dark field illumination, the image
signal Xi has a certain value at the mark edge position and
a value of black level at the remaining portions. A signal

5   obtained by differentiating the image signal Xi is a
differential signal Xid. When the scanning line is traced
from the left to the right, the differential signal Xid
becomes positive at the leading edge portion of the image
signal Xi and negative at the trailing edge portion.

10   A threshold value thl is set on the positive side of
the differential signal Xid. When the differential signal
Xid is binarized using the threshold value thl as a
reference, a left edge signal Le is obtained. In a similar
way, when a threshold value thr is set on the negative side

15   of the differential signal Xid, and the signal Xid is
binarized using the threshold value thr as a reference, a
right edge signal Re is obtained. The left edge signal Le
represents the left edge position of the mark image, and
the right edge signal Re represents the right edge position

20   of the mark image. When the above processing is executed
for all scanning lines, pieces of edge information
representing the left edge positions of the mark image and
pieces of edge information representing the right edge
positions are obtained.

25   An image signal along a vertical line (column) on the
image memory is represented by Yi. Like the image signal

Xi, the image signal Yi is traced from the lower side to the upper side, and a differential signal Yid is generated. When the differential signal Yid is binarized using threshold values thu and tho, an under edge signal Ue and

5   over edge signal Oe are obtained. The under edge signal Ue represents the under edge position of the mark image, and the over edge signal Oe represents the over edge position of the mark image. When the above processing is executed for all vertical lines, pieces of edge information

10   representing the under edge positions of the mark image and pieces of edge information representing the over edge positions are obtained.

In Fig. 4A, edge information representing the right edge positions, edge information representing the left edge

15   positions, edge information representing the over edge positions, and edge information representing the under edge positions all of the mark 100 are synthesized and two-dimensionally illustrated. In this embodiment, as edge position images (edge information and attribute

20   information), edge information associated with attribute information "over" shown in Fig. 4B, edge information associated with attribute information "under" shown in Fig. 4C, edge information associated with attribute information "left" shown in Fig. 4D, edge information

25   associated with attribute information "right" shown in Fig. 4E are stored in the processor 72 as independent

information.

Mark image search (S101) is performed by matching calculation of templates stored in advance and edge position images (edge information) shown in Figs. 4B to 4E.

5   Figs. 5A to 5E are views for explaining the templates.

Since the positions of the over, under, left, and right edges relative to the mark center (cross) are known, the templates are registered as layouts shown in Figs. 5B

10   to 5E in which feature portions of the mark are indicated by open circles. That is, the templates can be determined on the basis of the shape of the mark to be formed on the wafer. Fig. 5A shows the synthesized image of the four registered templates shown in Figs. 5B to 5E. In this

15   embodiment, the position of an open circle is called a feature point of interest, and a set of points of interest is called a template. In each template of this embodiment, feature points of interest are defined on only one side edges of the mark. For example, in the template shown in

20   Fig. 5B, the feature points of interest are defined on only the over edges of the mark.

Matching calculation in mark image search is performed by determining whether, e.g., the pieces of edge information shown in Fig. 4B are present at the positions

25   of open circles in Fig. 5B with reference to the mark center (cross). In a similar way, Fig. 4C and Fig. 5C, Fig. 4D

and Fig. 5D, and Fig. 4E and Fig. 5E are compared to
determined whether the pieces of edge information shown in
Figs. 4C to 4E are present at the position of open circles
in Figs. 5C to 5E, respectively. When the edge information

5   are present at all the hollow bullet positions, the degree
of matching is 100%. If some hollow bullet positions have
no edge information, the degree of matching is lower than
100%. The above matching calculation is performed for the
entire edge images while changing the mark center

10 coordinates, and mark center coordinates at which the
degree of matching is highest are finally extracted,
thereby completing the search.

     The feature points of interest shown in Figs. 5B to
5E are defined by thinning out points and designating two

15 points that define specific edges. Even when the number
of feature points of interest is increased, no effect is
obtained unless they express the characteristic feature of
the mark shape. If the feature points of interest are
densely defined, the degree of matching becomes low due to

20 various reasons, and the mark image may not be detected.
Especially, when the mark is damaged, the degree of matching
often extremely lowers. For this reason, a high detection
rate can be stably obtained by setting thinned out feature
points of interest, as described above.

25   Vector correlation has been described above.
     When the maximum degree of matching obtained by the

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above-described search is lower than the level of threshold value for determination, the coordinates at which the maximum degree of matching is obtained may not indicate the correct mark position. In this case, edge information

5   extraction may be not optimum. Hence, preferably the threshold values thl, thr, thu, and tho used for extraction of mark edge information are corrected, the edge information are generated again, and search is repeated.

For example, when the threshold values thl, thr, thu, and tho for edge extraction are originally relatively large, no edge information is obtained from a low-contrast mark image. Hence, the degree of matching in search is low, and mark detection determination is impossible. Preferably, the edge information of the mark is detected while gradually

15   decreasing the threshold value for edge extraction. This makes it possible to obtain a sufficient degree of matching in search.

As another example, when there are a plurality of coordinates at which a degree of matching higher than the

20   level of threshold value for determination, the mark position cannot be determined. In this case as well, the mark position can be reliably determined by increasing the determination threshold value and repeating edge information generation and search.

25   The position detection parameter such as the threshold value for edge extraction or threshold value for

determination can be efficiently changed by storing, e.g.,

a value determined according to the immediately preceding

search processing result (degree of matching) in the memory

and using the value as the base (e.g., initial value) for

5   detection parameter determination of the next time.

For precise detection (S103) after the end of mark

image search, the mark position can be determined at an

accuracy beyond the pixel resolution by, e.g., a method of

obtaining the barycenter on the basis of the luminance

10   distribution with an origin set at the center coordinates

of the A/D-converted image found by the search.

In this embodiment, edge extraction is performed

immediately after image reception. Processing of

performing noise removal filtering before edge extraction

to lower the noise level in advance and prevent any

unnecessary edge information, or forming a bold line image

as edge information to correct deformation in mark size or

omission of edges is also effective. Processing of

adjusting the noise removal parameter or bold line

20   formation parameter is also effective. Addition of the

above processing results in an increase in detection rate

in mark search.

In the first embodiment, the position detection

apparatus of the present invention and the semiconductor

25   exposure apparatus using the position detection apparatus

are applied to pre-alignment using the off-axis scope 6.

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However, the processing of mark position search is not limited to pre-alignment using off-axis.

Fig. 2B shows the second embodiment in which the position detection apparatus of the present invention is applied to a TTR detection system for detecting a mark on a wafer 5 or stage through a reticle 1 in a semiconductor exposure apparatus.

To detect a mark in the TTR detection system, exposure light is used. For example, in a semiconductor exposure apparatus using an excimer laser, a CCD camera 7 and laser 21 are synchronized by a sync signal generator 20 to emit a laser beam only during the light storage time of the CCD camera 7. For the photoelectrically converted mark image, the mark position search is done by the same method as in the first embodiment, and after the search, an accurate mark position can be calculated. In an i-line exposure apparatus, since the light source is not a laser, synchronization between image reception and the illumination system is unnecessary. For this reason, the mark position search can be done, and accurate mark position calculation can be performed after the search, as in the first embodiment.

In reticle alignment for alignment the reticle 1 with respect to a projecting lens 2 as well, the same processing as in the first embodiment can be performed for a mark search.

Fig. 2C shows the third embodiment of the present invention in which the position detection apparatus of the present invention is applied to a TTL detection system for detecting the mark position on a wafer 5 or stage 3 through a projecting lens 2 without interposing a reticle 1 in a semiconductor exposure apparatus. In TTL as well, the mark search and position determination can be performed by the same method as that of the first embodiment except that the mark image sensing method is different.

As has been described above, in the position detection apparatus according to the preferred embodiment of the present invention and the semiconductor exposure apparatus using the position detection apparatus, the edge information of a mark image is extracted in correspondence with attribute information, the edge information is compared with a corresponding template in units of partial edges on the basis of the attribute information, and the obtained comparison result is evaluated, thereby determining the mark position. Since it can be determined at high probability in units of partial edges whether a partial edge (e.g., Fig. 4B) and a template (e.g., Fig. 5B) corresponding to the edge match, the probability of mark position detection becomes higher than that of the prior art in which it is determined whether the entire mark image matches the template. Hence, according to this embodiment, the position of the image of a mark with degradation or a

defect generated in manufacturing a high-density

semiconductor device, e.g., a low-contrast mark image, a

noisy mark image, or a mark image obtained by sensing a

defect generated in the wafer process can be more stably

5   detected.

As a consequence, in this position detection

apparatus and semiconductor exposure apparatus using the

position detection apparatus, by repeating pattern

matching while adjusting one or both of the edge extraction

10   parameter and parameter used to determine the matching

result in accordance with the result of template matching,

the image of a mark with degradation or a defect can be more

reliably detected.

The present invention is not limited to the above

15   embodiments and various changes and modifications can be

made within the spirit and scope of the present invention.

Therefore, to apprise the public of the scope of the present

invention, the following claims are made.